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PROCEEDINGS OF THE US ARMY CORPS OF ENGINEERS RIPARIAN ZONE RESTORATION AND MANAGEMENT WORKSHOP 24-27 FEBRUARY 1986

by

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Environmental Laboratory

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Riparian zones are extremely valuable and sensitive ecosystems, and their proper management and protection are important considerations for Civil Works projects. The development and management of riparian habitats may also be viable mitigation alternatives for many US Army Corps of Engineers projects. To address these issues, a new research and development work unit entitled "Development of Guidelines for Riparian Zone Restoration and Management" was approved in 1986 by the Office, Chief of Engineers, US Army.

This report presents the findings of a Corps of Engineers workshop on riparian zone restoration and management held in San Antonio, Tex., on 24-27 February 1986. The purpose of the workshop was to develop the concept of the riparian zone work unit and ensure that the study addressed planning and operational needs within the Corps. Topics discussed included ecological studies in riparian habitats, inventory and preservation of project-related riparian areas, development of environmentally beneficial designs for local flood

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Biotechnical methods	Riparian corridors
Buffer strips	Riparian ecosystems
Corps of Engineers	Riparian zone management

19. ABSTRACT (Continued).

protection projects, riparian habitats associated with multipurpose reservoirs, riparian problems in urban settings, and restoration of riparian vegetation and associated wildlife habitat through the use of bioengineering techniques.

Major riparian concerns expressed by workshop participants are summarized as follows. Corps projects are strongly influenced by surrounding land uses, including agriculture, grazing, industry, urbanization, and recreation. Adverse impacts of these activities are often detrimental to the riparian zone and the stream itself, especially where a protective buffer strip is not established and maintained as part of the project plan. A major concern at most Civil Works projects is the provision of bank protection and shoreline stabilization to prevent erosion and sedimentation and to reduce adverse impacts of project construction. It was agreed that bank restoration and stabilization are best achieved through a bioengineering approach using native plant materials as much as possible. All District and Division representatives reported that riparian zone planning and management were important environmental issues within their areas of jurisdiction. Riparian habitats are concerns of both Planning and Construction-Operations functions within the Corps of Engineers, and a need was expressed for the Corps at large to recognize the broad environmental values and national significance of riparian ecosystems and to develop strategies and guidance for their protection and management.

Major tasks identified for the work unit are to: (a) synthesize available information on riparian zones and develop a procedure for transferring technology to the field; (b) coordinate work unit activities with other government agencies and organizations; (c) conduct a broad analysis of riparian functions and values; (d) provide information on bioengineering approaches to vegetation establishment and bank protection appropriate for riparian zones; (e) include riparian zone restoration and management as a topic to be addressed by the Chief of Engineers' Environmental Advisory Board; (f) obtain information on riparian zone management programs at Corps projects and prepare a report of case studies; (g) survey site-specific riparian management activities at Corps projects for analysis and assessment; and (h) produce a Corps of Engineers guidance document on proper procedures for riparian restoration and management.

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PREFACE

This work was sponsored by the Office, Chief of Engineers (OCE), US Army, as part of the Environmental Impact Research Program (EIRP), Work Unit 32391, entitled "Development of Guidelines for Riparian Zone Restoration and Management." The Technical Monitors for the study were Dr. John Bushman and Mr. David P. Buelow, OCE, and Mr. Dave Mathis, Water Resources Support Center.

This report was prepared by Mr. Chester O. Martin and Mr. Hollis H. Allen, Wetlands and Terrestrial Habitat Group (WTHG), Environmental Laboratory (EL), US Army Engineer Waterways Experiment Station (WES). Corps of Engineers District and Division representatives prepared individual papers and are cited as authors within the report. Manuscript reviews were provided by Dr. James S. Wakeley, Dr. Charles V. Klimas, and Dr. Hanley K. Smith, EL.

Work was performed under the general supervision of Dr. Hanley K. Smith, Chief, WTHG; Dr. Conrad J. Kirby, Chief, Environmental Resources Division; and Dr. John Harrison, Chief, EL. Dr. Roger T. Saucier, WES, was Program Manager, EIRP. The report was edited by Ms. Lee T. Byrne of the WES Information Products Division, Information Technology Laboratory.

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CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
acres	4,046.873	square metres
acre-feet	1,233.489	cubic metres
degrees (angle)	0.01745329	radians
feet	0.3048	metres
gallons	3.785412	litres
inches	25.4	millimetres
miles (US statute)	1.609347	kilometres
pounds (mass)	0.4535924	kilograms

PROCEEDINGS OF THE US ARMY CORPS OF ENGINEERS RIPARIAN ZONE RESTORATION AND MANAGEMENT WORKSHOP, 24-27 FEBRUARY 1986

PART I: INTRODUCTION

A Corps of Engineers workshop on riparian zone restoration and management was held in San Antonio, Tex., on 24-27 February 1986. The purpose of the workshop was to present the concept of a new Environmental Impact Research Program (EIRP) work unit entitled "Development of Guidelines for Riparian Zone Restoration and Management" (Work Unit 32391) and to ensure that the study addressed major planning and operational needs within the Corps.

The workshop was convened on 25 February with Mr. Hollis H. Allen and Mr. Chester O. Martin, US Army Engineer Waterways Experiment Station (CEWES-ER-W), serving as workshop coordinators; participants are listed in Appendix A. Mr. Allen stated the objectives and scope of the workshop and presented the preliminary plan of study for the riparian work unit. Mr. Martin gave an overview of riparian concerns applicable to the Corps of Engineers. District and Division representatives made presentations on riparian habitat activities and issues within their areas of jurisdiction. Presentation summaries are provided in the next section of this report. Each presentation was followed with a short discussion period, and an extensive group discussion was held after all presentations were completed. Mr. Phil Pierce, Office, Chief of Engineers, provided commentary on riparian zone issues.

A field trip was taken to riparian localities north of San Antonio on 26 February. Arrangements and support for field activities were provided by the Fort Worth District through Mr. Marty Hathorn. Access to sites and technical assistance were also provided by the Texas State Nature Conservancy, Texas Parks and Wildlife Department, and Canyon Lake staff of the Fort Worth District; Mr. Lee Hunt (ranger, Canyon Lake) accompanied workshop participants on the trip and provided logistical support. Visits were made to the Guadalupe River State Park and Honey Creek Ranch, owned by the Texas Nature Conservancy; riparian areas upstream of Canyon Lake; backwaters of Canyon Lake; and riparian areas along the Guadalupe River downstream of Canyon Lake. Workshop participants also had the opportunity to visit the highly urbanized San Antonio River.

The concluding session for the workshop was held on the morning of 27 February. Riparian issues were identified and discussed, and priorities for research and technology transfer were established. Major topics of discussion and results of the workshop are provided following the presentation summaries. The plan of study for the work unit is enclosed as Appendix B.

PART II: SUMMARIES OF PRESENTATION

DEVELOPMENT OF A RIPARIAN ZONE RESTORATION AND MANAGEMENT WORK UNIT FOR THE US ARMY CORPS OF ENGINEERS

Hollis H. Allen, Ecologist

Wetlands and Terrestrial Habitat Group, Environmental Laboratory
US Army Engineer Waterways Experiment Station

Riparian zones are extremely important and sensitive ecosystems, and their proper management and protection are often essential to achieving environmental benefits at Civil Works projects. The development and management of riparian habitats are also viable mitigation alternatives for many US Army Corps of Engineers (CE) projects. To address these issues, a new research and development work unit entitled "Development of Guidelines for Riparian Zone Restoration and Management" was initiated this fiscal year (FY 1986) by the Environmental Impact Research Program of the Office, Chief of Engineers, US Army; technical aspects of the study have been assigned to the Environmental Laboratory, US Army Engineer Waterways Experiment Station.

The work unit is designed to provide technology to Corps Districts on riparian habitat development, restoration, and management. This will involve an extensive survey of available information and coordination with other agencies and organizations. A survey of riparian habitat development and management will be made at Corps projects, and the results of these efforts will be analyzed. Preliminary topics identified for inclusion in the study are as follows:

1. Habitat development and revegetation methods suitable for riparian habitats.
2. Methods for erosion control and bank stabilization.
3. Design and development of buffer zones along riparian corridors.
4. Development of management strategies appropriate for riparian wildlife habitats.

Streambank restoration and stabilization are major concerns for both engineers and biologists at many Corps projects. Bank erosion may adversely affect water quality, fish and wildlife habitats, and project features. Several Districts are now using a combination of engineering structures and vegetation to provide stable and vegetated shorelines. For example, the Missouri River Division is using composite revetments and vegetation plantings on the upper Missouri River. The Little Blue River project near Independence, Mo., is an example of benefits produced when proper flood-tolerant vegetation is used for riparian habitat development.

Several biotechnical methods commonly practiced in Europe offer considerable potential for streambank erosion control in the United States. One method employs the placement of a brush mattress bolstered at the toe with brush bundles or riprap; the brush is composed of live, sprouting, flood-tolerant woody species whose roots serve to bind the soil. Other techniques, such as plant rolls and brush mats, are also available and should be considered for bank protection at Corps projects.

There are many situations, especially in the West, where streams or rivers are essentially devoid of vegetation; thus, there is no cover for wildlife and little shade for fish and other aquatic organisms. In such cases, the development and protection of vegetated buffer strips should be a major management objective. Protection of these sites from heavy grazing pressure and incompatible recreation activities should be an important consideration. Buffer strips were developed through plantings along the Snake River, Washington and Oregon, in the Walla Walla District; these efforts were largely part of a mitigation program and have resulted in substantial improvements to wildlife habitat. The Stanislaus River Parks system (Sacramento District) in central California is another example of wildlife habitat improvement resulting from riparian zone protection and restoration; fisheries benefits were also achieved by providing shade and managing gravel bar habitat.

The work unit has broad application to the Corps of Engineers because many projects (e.g., local flood control, permit actions, reservoir operations) influence riparian systems. Thus, riparian concerns are important to a variety of Corps functions and involve CE Planning, Engineering, Construction-Operations, and Regulatory offices. Although several Districts are actively managing streamside areas, there is currently no Corps of Engineers guidance

on restoration and management practices appropriate for Civil Works projects. Information developed through the work unit should be applicable to Corps projects nationwide.

AN OVERVIEW OF THE STATUS OF RIPARIAN ECOSYSTEMS AND THE APPLICATION OF RIPARIAN ZONE MANAGEMENT TO CORPS PROJECTS

Chester O. Martin, Wildlife Biologist

Wetlands and Terrestrial Habitat Group, Environmental Laboratory
US Army Engineer Waterways Experiment Station

The protection of dwindling riparian resources has been an important environmental issue in the United States since the 1960s. To address the problem, several government agencies have developed programs that deal specifically with riparian ecosystems, and three national and international symposia (in 1977, 1978, and 1985) have been sponsored by the US Forest Service and National Park Service along with other Federal and State agencies, universities, and private organizations; the US Army Corps of Engineers participated as a cosponsor of the 1978 symposium. Additionally, a forum dealing specifically with grazing impacts on riparian zones was published by Trout Unlimited in 1979, and several State and regional workshops have been held. Reports or summaries are available for most of these meetings.

Several Corps offices have also conducted studies on riparian habitats associated with their projects. The North Pacific Division has published inventories of riparian zones associated with the Snake and Columbia Rivers, Washington and Oregon, and the lower Clearwater River in Idaho; the Sacramento District has recently completed a draft riparian planting design manual for their project lands; and several riparian restoration and monitoring studies are being conducted by the Albuquerque District. Other Corps studies and activities will be presented later in this workshop.

To provide a basis for discussion of riparian habitats and their importance to the Corps of Engineers, I will briefly summarize the following concepts and issues: characterization of riparian ecosystems, values and benefits of riparian corridors, and riparian problems and conflicts.

Characterization

A variety of definitions have been proposed for riparian zones, but for the present we will simply consider them broadly as ecosystems associated with streams and rivers. Common features usually identified with riparian zones are as follows:

1. Riparian zones are ecotonal in nature, occurring between aquatic and upland ecosystems; however, they tend to have distinct vegetation and soil characteristics.

2. They have elongate shapes and often have very high edge-to-area ratios.

3. Riparian zones are characterized by a combination of high species diversity, high species densities, and high productivity.

4. Functionally, there are continuous interactions among riparian, aquatic, and upland ecosystems through the exchange of energy, nutrients, and species. This exchange is active in mobile organisms but also occurs passively with flooding events.

Depending on their location, riparian habitats may be variously referred to as alluvial floodplains, riverine wetlands, floodplain forests, bottomland habitats, bosque woodlands, stringer woodlands, or gallery forests. In the West, vegetation zones tend to be sharply delineated, and there is a distinct contrast between the streamside area and adjacent xeric habitats. Vegetation zones are usually much wider in the East, and a broader ecotone usually occurs between the stream and upland habitats. However, in agricultural regions much of the ecotone has been eliminated, and the riparian corridor has become structurally and functionally more similar to Western situations.

Values and Benefits

The inherent values of riparian zones have been documented in numerous studies. Some of the widely accepted benefits resulting from protection and restoration of riparian corridors in their natural state are as follows:

1. Riparian zones function as a buffer to protect streams and rivers from the potential impacts of adjacent land uses. As such, they serve as a filter to ameliorate the effects of agriculture, industry, and urbanization on water quality and aquatic resources.

2. Stable riparian vegetation reduces streambank erosion, provides shade, and contributes organic matter to the stream, thereby improving water quality and fish habitat.

3. Riparian ecosystems are aesthetically important and offer scenic relief from monotonous man-made landscapes such as agricultural, residential, and industrial areas. In many areas, establishment of greenbelts along waterways has become an important part of urban and regional planning.

4. Riparian zones provide important recreational opportunities for both consumptive and nonconsumptive purposes.

5. Riparian ecosystems are extremely important wildlife habitats. They provide essential food and cover for a variety of species, provide critical nesting habitat, serve as corridors for movement, and allow access to available water. Nationwide, a disproportionate number of fish and wildlife species depend on riparian habitats for survival; these include many threatened and endangered species.

Problems and Conflicts

Besides the natural value of riparian ecosystems, there are substantial economic gains that can be derived from the use of these corridors. Some sources of conflict in resource use are listed below.

1. Rich bottomland soils are of high value for crop production; where no buffer strip is left intact, soil erosion and runoff of agricultural chemicals often occur.

2. The quality and high production of forage often make riparian grasslands valuable as grazing lands.

3. Industrial development often occurs along waterways.

4. Riparian zones tend to attract high-density recreation activities that are often incompatible with maintaining habitat quality.

5. Their aesthetic appeal and proximity to recreational opportunities (coupled with flood insurance subsidies) make riparian zones attractive to urbanization.

6. Civil Works projects modify natural flows and divert ground and surface waters, thus producing substantial alterations to riparian habitats.

The direct and indirect impacts of Civil Works activities will be major topics of discussion for the workshop. The following District and Division presentations address specific riparian zone problems and measures taken to restore and/or manage these corridors.

RIPARIAN ECOSYSTEM MANAGEMENT IN THE WILMINGTON DISTRICT

William F. Adams, Biologist

Planning Division, Environmental Resources Branch
US Army Engineer District, Wilmington

Local flood protection projects have been the major focus for riparian zone restoration and management efforts in the US Army Engineer District, Wilmington. Riverine shoreline erosion has not been a major management concern in the District, as inland navigation traffic is not heavy. Although shoreline erosion occurs at District reservoir projects, the extent of the problem has not warranted major management efforts to date.

A variety of design features have been incorporated into local flood-control projects to minimize their impacts on riparian ecosystems and improve their aesthetic appearance. Local flood-control projects include stream channelization (authorized under Section 205 of P. L. 80-858, as amended) and clearing and snagging projects (Section 208 of P. L. 83-780, as amended). Environmental design features have been incorporated into both channelization and clearing and snagging projects and have potentially wide application. These features are briefly described below. (It should be noted that these features may not be applicable in every situation. Site adaptation may also be needed, and future maintenance requirements and costs must be considered).

Channelization Project Measures

1. Project construction should be allowed only on the bank that makes the lesser contribution to stream shading. This confines disturbance of the riparian zone to one side of the stream and retains the stream-shading function provided by riparian vegetation on the opposite side.

2. No disturbance should be allowed on the off-bank (side of stream not receiving construction) except for cutting trees that lean more than 30 deg* from vertical. This reduces future bank maintenance by taking out only those trees most likely to fall, while maintaining riparian zone integrity.

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* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

3. Tree "clumps" (consisting of several small trees or one large tree) can be left at intervals along the construction side. This provides habitat diversity and additional stream shading. Retaining mast-producing species is recommended.

4. All tree stumps can be left intact. Leaving the stumps reduces erosion by binding soil and hastens revegetation through stump sprouting.

5. Disposal mounds and travelways should be breached to permit water interchange between swamplands and the stream during flood events.

6. Wildlife food mixes should be planted on construction travelways, and shrubs and trees should be planted on disposal sites.

7. Woody debris removed from construction rights-of-way need not be burned; an alternative is to stack the material in riparian areas to provide cover for small mammals, reptiles, and amphibians.

8. Construction travelways should be gated after project completion to prohibit vehicle access.

9. Bench (overflow) channels can be constructed to improve the hydraulic efficiency of the stream, while preserving the existing stream bottom.

10. Bikeways and walkways can be constructed along streams in urban areas.

11. Ornamental trees and shrubs can be planted in urban areas.

12. Mitigation lands should be purchased and managed where necessary.

Clearing and Snagging Project Measures

1. Only trees leaning more than 30 deg from vertical should be cut.

2. All tree stumps should be left intact.

3. Only loose snags (those not embedded) should be pulled out.

4. When a snag is embedded, only the portion above the summer low-water line should be cut.

5. Removed snags should be pulled back and placed in the riparian zone.

6. Only wide-tracked vehicles should be used when working in riparian areas.

7. Only trees or shrubs less than 6-in. diameter at breast height should be cut for construction access.

The above measures represent project features that have recently been incorporated into the Wilmington District's flood-control projects. Examples of projects that have, or will contain, many of these features are the Joyce

Creek project in Camden County, N. C., the Great Coharie Creek project in Sampson County, N. C., and the Roanoke River project in Roanoke, Va. Bench channels were constructed along the Ararat River in Mt. Airy, N. C., and are proposed for use on the Roanoke River.

Conclusions

Projects planned today are incorporating features that make them more environmentally acceptable. The current emphasis for flood-control projects is to keep work out of the stream as much as possible. The following problem areas have been identified as major concerns in riparian ecosystem analysis and management:

1. Assessing fisheries and wildlife impacts associated with reduced frequency of flooding in riparian areas.

2. Assessing fisheries and wildlife impacts associated with reduced flood stages in riparian areas.

3. Mitigating impacts associated with 1 and 2, above.

4. Assessing water quality impacts associated with reduced overbank flooding.

Other management measures under consideration for future projects in the District include (a) potholing of riparian areas to provide additional standing water, (b) killing selected trees by girdling or chemical injection to release tree stands and provide dead trees for snag or cavity nesters, (c) installing wood duck and/or squirrel nest boxes, and (d) placing limited amounts of structure (rocks and large woody debris) in the stream to serve as fish attractants and surfaces for the attachment of aquatic invertebrates. The field of riparian ecosystem management holds great promise for further refinement of the procedures listed above and for the development of new and innovative techniques.

ENVIRONMENTAL STUDIES OF SHORELINE WETLANDS AND AQUATIC HABITATS IN THE BUFFALO DISTRICT

James Bennett, Community Planner

Chief/Environmental Branch, Asst. Chief/Planning Branch
US Army Engineer District, Buffalo

The US Army Engineer District, Buffalo, has conducted and contracted a number of ecological studies on water resources projects since the inception of the National Environmental Policy Act. Today I will present information on two projects, the Lake Ontario Shoreline Protection Study and the St. Lawrence River Study. Field work for both studies was conducted by the US Fish and Wildlife Service (FWS) and Corps biologists after detailed scopes of work were developed.

Lake Ontario Shoreline Protection Study

The Lake Ontario study was conducted in the summer of 1980. The objective was to examine the possible impacts of changes in the Lake Ontario water-level regulation plan on shoreline wetlands. Two wetlands were selected for investigation: (a) Campbell Marsh--a streamside wetland approximately 70 acres in size in Jefferson County, N. Y., and (b) Sage Creek Marsh--a flood pond system about 30 acres in size in Oswego County, N. Y. These marshes were selected as pilot study sites because they represent the type of areas most sensitive to changes in lake water levels. Several criteria were established for selection of the pilot study areas, and candidate wetlands had to be of a size that could be studied in their entirety.

Field studies consisted of evaluations of selected habitats within each wetland. Historical conditions in the wetlands were also examined from available published data. Field reconnaissance and aerial photograph interpretation revealed six habitat types at Campbell Marsh: (a) aquatic bed, (b) nonpersistent emergent, (c) persistent emergent, (d) grass/sedge, (e) scrub/shrub, and (f) deciduous forest. Four habitat types were defined at the Sage Creek Marsh: (a) aquatic bed, (b) broad-leaved nonpersistent emergent, (c) narrow-leaved nonpersistent emergent, and (d) grass/sedge.

Line transects were run through the different habitat types in the two wetlands. Water depth and species occurrence in each 1-m segment of transect

were recorded. Topographic maps with 1-ft contour intervals were prepared for each wetland. These showed that the two wetlands were relatively flat with areas some distance from Lake Ontario still under the influence of lake water levels. Mapping of present vegetative patterns showed that the different cover types occurred within rather distinctive elevational ranges. Historical photography substantiated that changes in vegetation occurred through time as water conditions changed. For example, much of Campbell Marsh is presently dominated by cattail (*Typha glauca*), whereas grasses and sedges were previously more abundant at both similar and lower water levels.

Results from these pilot studies have shown that the two wetlands examined are not sufficiently representative of all wetlands found along Lake Ontario and the St. Lawrence River. Additional wetlands representing a variety of types and geographic locations need to be examined to better understand the entire system. The FWS recommended that a total of 15 different wetland types, as well as selected shoal and beach areas, should be examined for the Lake Ontario/St. Lawrence River shoreline.

St. Lawrence River (Additional Lock Study)

The St. Lawrence River ecological study was conducted from 1983 through 1985. The study area included the St. Lawrence River from the vicinity of Clayton, N. Y. (where Lake Ontario enters the St. Lawrence River) downstream to Massena, N. Y.--a distance of about 70 miles. The study was divided into two parts: Part A involved a detailed review of historical natural resource information and habitat changes in the International Section of the St. Lawrence River, and Part B involved a detailed biological survey of fish, benthic, and botanical resources.

The first part of the study required mapping habitats for three time periods: prior to seaway construction, shortly after seaway construction, and during current conditions. Habitat types included shallow bays, rocky outcrops or shoals, mud flats, deep channels (greater than 15 ft), shallow channels, wetlands, beaches, and upland areas adjacent to aquatic habitats. Supportive information was collected on watershed characteristics, geomorphology, geological history, climatology, water quality, water level changes, hydrology, and current and historical land uses.

The description of biological components focused on fish and selected warm-blooded vertebrates relative to productivity, nutrient dynamics, detrital

and organism fluxes, food webs, and spatial and temporal distribution. Index species (predominantly fish) were selected for discussion of life history strategies. Part A studies terminated in a report entitled "The St. Lawrence River--Past and Present" dated April 1984,* which also identified information gaps that need to be filled to better understand the ecosystem. Information gaps addressed were limited to those that would provide data needed to evaluate changes in the river system resulting from navigational alterations (either due to construction or operation).

The Part B portion of the study involved biological sampling for the 1984-85 field seasons. Transects were established through potential dredging (channel widening) sites in the study area to collect data on fish eggs, benthic invertebrates, and aquatic macrophytes. As part of this effort, the FWS developed a "vacuum pump" device to collect fish eggs; detailed information can be provided on this unique device upon request. A two-volume report on the Part B studies was completed by the FWS in June 1986.**

Conclusions

Although neither of the ecological studies accomplished to date on Lake Ontario and the St. Lawrence River includes all the information needed to determine all the impacts of dredging, water-level changes, or construction of additional locks, results have added substantially to the existing data base. These studies represent a significant step in helping the District gain insight into the complex ecosystem of Lake Ontario and the dynamic ecosystem of the St. Lawrence River with its swift currents and numerous islands.

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* U.S. Fish and Wildlife Service. 1984. The St. Lawrence River--past and present: A review of historical natural resources information and habitat changes in the International Section of the St. Lawrence River. Part A studies, April 1984. U.S. Fish and Wildl. Serv., Cortland Ecol. Serv. Field Office, New York, (report prepared under contract to the U.S. Army Corps of Eng., Buffalo District).

** _____. 1986. A biological survey in the International Section of the St. Lawrence River--with special emphasis on aquatic macrophytes, fish spawning, and macroinvertebrates. Part B studies (2 Vol.), June 1986. U.S. Fish and Wildl. Serv., Cortland Ecol. Serv. Field Office, New York, (report prepared under contract to the U.S. Army Corps of Eng., Buffalo District).

RECOMMENDATIONS FOR RIPARIAN ZONE RESTORATION AND MANAGEMENT STRATEGIES BASED ON PROJECT STUDIES IN THE NEW YORK DISTRICT

M. Lou Benard, Environmental Resources Planner

Planning Division, Passaic River Study Group
US Army Engineer District, New York

The Passaic River Basin Study is a major planning responsibility of the US Army Engineer District, New York. Although a comprehensive flood-control plan is being developed for the main stem Passaic River and its tributaries, several substudies have been conducted to formulate local flooding solutions independent of the main study. One such local project protects the Ramapo and Mahwah Rivers, located in Mahwah, N. J., and Suffern, N. Y. Phase I Engineering and Design studies have been conducted for these rivers and their floodplains. Based on problems that arose during interim project studies, the following recommendations are made for the Corps of Engineers riparian zone restoration and management work unit.

Recommendations

1. Develop rules of thumb for the sizes and spacing of rocks and logs that could be placed on a river's side slopes but would not cause debris jams during flood stages. The sizing should be proportional to channel width, mean depth, and velocities during flood stages. Specify minimum design requirements for reptile and amphibian (herptile) habitats; this is important because herptiles are essential biological components of riparian ecosystems but are often ignored in the assessment of project impacts. Include information on ground cover that would create the microclimate herptiles require for survival.

2. Prepare regional lists of indigenous riparian vegetation, including trees, shrubs, herbs, grasses, and wildflowers, emphasizing species that serve as wildlife food and cover. Provide detailed planting instructions for native vegetation, including detailed scopes of work for landscaping contractors. A Corps-wide goal should be to restore riparian habitats as much as possible to their original condition using native vegetation.

3. Analyze the benefits and costs of inventorying and using existing natural materials at the construction site for replanting and beautifying the finished product. This should include the use of boulders to diversify aquatic habitats, the use of rocks and logs to create herptile habitats on side slopes, and the use of gravel to create riverside nature trails. Traditionally, project estimates include the cost of hauling these materials away (to the benefit of the contractor) in addition to the cost of purchasing newly quarried rocks for riprap, macadam for trails, etc., and then hauling them to the site.

Another facet of this suggestion involves inventorying and preserving the existing riparian habitat as an integral part of the project. This should include a photoinventory of the site prior to construction. Nursery machinery capable of picking up shrubs and even trees (up to 12 in. in diameter) by their roots could be used to remove selected plants and haul them to a temporary staging/storage area during construction. During storage, the roots should be protected by burlap bags and watered as necessary. The trees and shrubs would then be replanted after the project is completed. If it is possible to protect riverside shade trees and bushes, they should be marked and fenced to protect them during construction. Postconstruction photos would hold the contractor to replacing damaged trees that should have been preserved. If some trees must be cut, they should be positioned in the understory to provide herptile habitat, or the wood could be used to build riverside benches, exercise stations, or other recreational structures. This suggestion would be more cost effective than the traditional procedure of clearcutting and grubbing of sites and replacing mature trees with newly purchased saplings.

4. Investigate newly developed construction materials, comparing their relative merits, costs, and deficiencies. For instance, soil filter fabrics could be used to hold the soil in place while riparian vegetation reestablishes itself. What would be the optimal thickness of soil filter fabrics and the optimal pore size for different soil types and flood velocities? Should the fabrics be permanent or biodegradable? Should these fabrics be used under riprap? Could they be used instead of riprap or in concert with densely rooted plants to replace riprap?

5. Because so many Corps projects appear sterile (i.e., lined with concrete or closely trimmed grass), investigate the feasibility of incorporating indigenous riparian herbs and forbs on the side slopes of modified channel reaches. This should include designing channel cross sections that are slightly wider than required to convey floodwaters in order to compensate for greater energy losses due to side slope friction. Friction losses from the herb and forb layer should be compared with friction losses from grassed slopes so that these values can ultimately be programmed into Hydrologic Engineering Center (HEC) models. Soil erosion should also be measured and compared at these sites. Consider covering slopes between the plants with stones or soil filter fabrics, particularly during initial plantings.

Incrementally optimize this concept by designing a still wider cross section of the river and planting even more densely rooted low-growing shrubs, and test these species under flood conditions. Is there more or less erosion from planting densely rooted riparian plants? Do the planted shrubs confer greater or less stability to the side slopes during flood stages? In reaches where riprap is required, could low shrub plantings be placed on the side slope along the upper boundary of the riprap, thereby reducing the amount of transitional riprap required and ameliorating the losses in aesthetics, wildlife habitat, cover, and shade? Investigate the feasibility of planting among the riprap stones to ameliorate these same losses. Compare the costs of using grasses that require repeated mowing with the cost of the suggested side-slope perennial plantings that are self-maintaining at their maximum height. Attempt to determine the monetary value of perennial plantings for wildlife food and refuge as well as for their aesthetic value.

6. Explore the application of existing computerized software packages for riparian planning. For example, Harvard University Graduate School of Design's laboratory for computer graphics and spatial analysis has two programs (called SYMAP and ASPEX) that could be used for riparian zone planning. ASPEX is a computer program that produces oblique perspective views of three-dimensional surfaces with a pen plotter and allows the definition of the viewing angle (azimuth and altitude). Both the line of site and viewing distance may be specified.

These programs could be applied to riparian planning activities as follows. River reaches that would be affected can be modeled with hydraulic and

hydrologic data that are already available and are being used to run the HEC models. ASPEX can show perspectives from the river to (a) existing trees, structures, and wetlands; (b) planned levees; and (c) planned levees with mitigative plantings. For detailed plans and specifications, a perspective view of the present landscape in the floodplain can be created using existing HEC cross sections. The location and height of trees and large understory bushes can then be specified, and the computer can be directed to map the view of the current floodplain using summer sun angles to simulate existing shade patterns over the river. A predictive representation of the modified floodplain (with the project implemented) can be created using the HEC models. The user can determine where trees and shrubs are needed to maintain similar shade patterns for mitigation. This package could also be useful in optimizing locations for aquatic habitat structures.

Comments

In conclusion, there is a fundamental problem concerning riparian mitigation in the Northeast that is beyond the scope of research efforts. Rather, it is a policy issue and must be addressed at the Washington, DC, level. The problem is that through long-term environmental degradation, urban riparian systems have been all but destroyed, and no one fishes, swims, or boats in these rivers. Because of this lack of use, it is extremely difficult to show project benefits for habitat restoration, and there is no mechanism to reflect improved water quality or the potential uses of the re-created riparian systems. There is also no established procedure for determining the monetary value of fish and wildlife benefits for inclusion in the recently required incremental justification for mitigation. Therefore, riparian systems are not able to achieve their potential as wildlife refuges and important recreational resources for the communities. I am hopeful that the work unit on riparian zone restoration and management can help Corps Districts in their efforts to re-create and manage riparian systems to the benefit of the region and the Nation.

RIPARIAN ZONE MANAGEMENT ASSOCIATED WITH RESERVOIR PROJECTS IN THE VICKSBURG DISTRICT

Grafton Anding, Wildlife Biologist

Operations Division, Project Resources Management Branch
US Army Engineer District, Vicksburg

The Project Resources Management Branch is responsible for managing seven reservoirs within the jurisdiction of the US Army Engineer District, Vicksburg. Four of these projects (Arkabutla, Enid, Grenada, and Sardis Lakes) are located in northern Mississippi and are managed primarily for flood control. Lake Greeson, Lake Ouachita, and DeGray Lake are located in Arkansas; these reservoirs are managed for both flood control and hydroelectric power production.

Corps lakes in Mississippi were formed by damming rivers and flooding the adjacent bottomlands, but their impoundment also resulted in the inundation of several thousand acres of upland habitat. The associated soils of these hills are highly erodible, poor in nutrients, and unstable in structure. Due to the characteristics of lake operation for flood control, water levels annually fluctuate in excess of 30 ft vertically and sometimes vary as much as 40 ft. As the lakes rise from the conservation pool to the flood-control pool (during winter and spring months), the shoreline increases in size, thus inundating the upland soils and exposing them to leaching, soil saturation, and wave wash. When the lakes begin to discharge and are lowered to their conservation pools (fall months), bank sloughing and erosion occur. The flood-control shoreline is usually exposed to drying conditions too late in the growing season to establish vegetative cover.

The Arkansas projects also inundated bottomlands and several thousand acres of upland areas, but these uplands consist of mountainous terrain characterized by rock ledges and steep bluffs. Consequently, fluctuations in lake elevations do not have much effect on the shoreline. In addition, the hydropower features of these lakes reduce the impact since water levels do not usually fluctuate more than 5 to 10 ft annually.

In an effort to reduce shoreline erosion (primarily on the Mississippi lakes), the Vicksburg District has used the protective measures described below:

Structural Methods

The use of concrete revetments, golbi blocks, riprap, and gabion mattresses has been successful from an engineering perspective. However, structural methods are extremely expensive in terms of materials and placement costs. Therefore, their use has been restricted to protection of dams, bridge piers, culvert facings, and shorelines adjacent to developed features such as recreation areas.

Stabilization structures (excluding riprap) are placed as follows. The site is first prepared so that a uniform surface is available for stabilization. This is accomplished by filling eroded areas with soil, sand, clay, gravel, or other suitable material. The site is then compacted, and structures such as golbi blocks, gabion mattresses, or concrete revetments are placed on the prepared surface. Placement of riprap is usually accomplished as follows: (a) the site is prepared to a specified slope, usually 1-ft vertical to 3-ft horizontal; (b) filter cloth (36-ft-wide strips of a plastic polymer yarn or fabric) is then applied to the site and fixed in place with securing pins; (c) a 12-in. layer of sand and an 18-in. layer of gravel are placed on top of the filter cloth; and (d) an 18-in. layer of riprap is spread uniformly over the gravel. Specific requirements and quantities of materials will, of course, vary from site to site.

The cost of these methods makes them appropriate only to large-scale erosion problems unless the structural integrity of a dam or important recreational or historical feature is in jeopardy. Other less effective structural alternatives used in the Vicksburg District include rubber tires, wooden fences, and concrete rubble.

Vegetation Establishment

The District has attempted to establish several species of annuals and woody plants to reduce wave wash and shoreline erosion. However, vegetative stabilization has proven largely unsuccessful because of the short growing season (due to the timing of reservoir inundation), shallow root systems, and saturated soil conditions. Only one species, baldcypress (*Taxodium distichum*), has been able to survive the harsh growing conditions, and

seedling establishment has only been successful in the upper reaches of the reservoirs.

Some site preparation is usually required prior to planting. This may simply consist of scarifying the soil or may involve turning the soil with a disk or other suitable implement. The amount of site preparation depends in part on the stability of the site (i.e., erodibility of soils, slope, etc.).

If the site is to be planted in annuals such as browntop millet (*Panicum ramosum*) or Japanese millet (*Echinochloa crusgalli* var. *frumentacea*), the soil should be scarified as soon as the lake is lowered and the ground is firm enough to hold the weight of a tractor. A soil sample should first be taken to determine the proper amounts of fertilizer and lime to be incorporated during site preparation. After the site is prepared, it is seeded at a rate of 25 to 35 lb/acre to produce a dense stand. Millets are preferred because they produce a thick root system, can usually endure extremes in growing conditions, and are dependable seed producers, which is an added benefit to wildlife. However, factors that limit the potential of these plantings are the short growing season (July to September), high temperatures during the growing season, and the shortage of rainfall. The benefits of millets are also limited because the plants are annuals and provide only one season of productivity.

If the site is to be planted in a woody species such as baldcypress, site preparation is usually not required or may consist only of removing surface vegetation that could impede planting efforts. Baldcypress seedlings are usually planted at a rate of 800 seedlings/acre. Baldcypress plantings have been more successful than other woody species because the seedlings can withstand extremes in growing conditions (from saturated soil conditions to periods when no surface water is available), they can withstand periods of inundation, and they can tolerate some wave action (the trees will survive if the soil around the roots is not completely washed away). Once the trees are established, root development and leaf litter help stabilize the soil. Establishing baldcypress also provides wildlife and aesthetic benefits.

Vegetative methods for soil stabilization have not been very successful on most reservoir drawdown areas in the Vicksburg District. Plants exposed to the harsh growing conditions, infertile soils, wave action, and slopes of the treatment areas either do not survive or become established at insufficient densities.

Therefore, vegetative methods are used mostly in protected coves and on large expanses of mud flats in the upper reaches of reservoirs where conditions are less extreme.

Comment

Riparian zone management and restoration concerns of the Operations Division primarily involve the protection of shoreline zones surrounding flood-control reservoirs. These management problems are also applicable to many other impoundments located in the Southeast. To date, very few cost-effective methods have been successfully demonstrated.

APPROACHES TO RIPARIAN ZONE RESTORATION AND MANAGEMENT IN THE FORT WORTH DISTRICT

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Major efforts to restore and manage riparian zones in the Fort Worth District are associated with multipurpose reservoir projects in the planning stage. Interdisciplinary planning efforts among environmental staff and project managers, design engineers, and hydraulic engineers for the most part provide satisfactory solutions to riparian zone problems on local protection projects in urban areas. Measures such as construction on only one side of the channel, grass-lined channels in lieu of concrete, tree wells on upper channel slopes to retain mature trees, and landscaping for asthetics and urban wildlife have been successfully incorporated into detailed project reports.

On operational reservoir projects, shoreline erosion problems exist that could potentially be addressed by vegetative treatments. These are not true riparian zones, however, and erosion is occurring because of the loss of xeric species. Shoreline stabilization on existing reservoirs might be achieved through plantings of wetland or more hydrophytic vegetation. On planning projects (for reservoirs), three general approaches are being used to address riparian zone management. These include the development of recreation corridors, mitigation of riparian losses, and environmental quality planning in the feasibility stage. The case studies described below illustrate each of the methods used for preserving, restoring, and managing riparian resources.

Ray Roberts Lake

Ray Roberts Lake is currently under construction; the damsite is located approximately 14 miles upstream from the headwaters of the existing Lewisville Lake in north-central Texas. Project authorization (1965) for construction of the new reservoir included raising the pool elevation of Lewisville Lake and acquiring and developing contiguous recreation lands and facilities. However, rapid urban expansion of the Dallas/Fort Worth/Denton metroplex has escalated

land costs adjacent to Lewisville Lake, thus precluding acquisition of perimeter lands for recreation purposes.

Releases from Ray Roberts Lake will create an enhanced recreation opportunity along the Elm Fork of the Trinity River between the two lakes. Therefore, an alternative recreation plan has subsequently been developed in the project master planning stage to acquire the riparian corridor (1,600 acres) between the lakes in lieu of traditional recreation developments originally planned for Lewisville Lake. This "greenbelt corridor" plan will prevent induced flood losses, protect water quality, and preserve the riparian zone between the two lakes. It has equivalent economic benefits; lower first costs; lower Federal costs; lower Operation, Maintenance, and Recreation costs; one additional recreation sponsor; partial State financing; management by the most appropriate agency; and broader public support than traditional facilities development. A Postauthorization Change Notification Report for the project has been forwarded to Congress for approval.

Applewhite Reservoir

The proposed Applewhite Reservoir would be located just outside the southwestern city limits of San Antonio, Tex., on the Medina River. The San Antonio Water Board has applied to the Fort Worth District for Section 404/10 Permits for construction of the dam. The lake would inundate approximately 1,100 acres of cypress (*Taxodium distichum*)-pecan (*Carya illinoensis*) bottomlands, which are categorized by the US Fish and Wildlife Service (FWS) as Resource Category 2. The riparian zone in the project area is extremely narrow, and in-kind mitigation would require a very long and narrow riparian corridor that could not be managed for hunting.

The FWS has stated opposition to granting permits for the project without mitigation for riparian habitat losses. As a result, and in coordination with the Texas Parks and Wildlife Department (TPWD), a mitigation plan has been developed that would include about 1,900 acres of riparian habitat in a 30-mile-long strip upstream of the lake. Narrowness of the corridor makes it unsuitable for hunting, but it provides excellent potential for low-density recreation (hiking and canoeing) and for nongame wildlife. The plan would mitigate 95 percent of the riparian habitat losses caused by lake construction. Management responsibilities for low-density recreation would be undertaken by either the San Antonio Parks and Recreation Department or the Parks Division of the TPWD. In the event that neither of these entities will

assume the task, the Wildlife Division of the TPWD will manage the area for nongame wildlife.

Rockland Lake

The Fort Worth District recently conducted a major feasibility study that considered preservation of riparian values. The Rockland Lake project on the Neches River in east Texas has been authorized since 1944. In 1985, the project was funded for a 1-year "Limited Reevaluation" to determine current feasibility. Part of that effort was a study to determine flows required to sustain the viability and productivity of the Big Thicket National Preserve. The Lower Neches River Corridor Unit of the Big Thicket is an overflow forest consisting of cypress and mixed hardwoods. An interagency study team composed of representatives from the FWS, TPWD, Texas Natural Resources Information System, and Fort Worth District was organized to determine hydrologic requirements of the Lower Neches Corridor.

The interagency study consisted of three major work efforts. The first was to correlate annual flow regimen with productivity as measured from tree rings, age class and species diversity, and soil indices. These productivity indices were measured on six 40-acre sample plots. The next effort was to interpret LANDSAT multispectral scanner (MSS) band intensities of the sample plots for an array of water years and to correlate MSS reflectance values with hydrologic regimen. The final task involved correlation of tree growth with flow parameters (depth, frequency, duration) at each sample plot and development of multivariate models to predict tree growth as an index of riparian hardwood productivity. The primary study objective was to design into the project an overbank flow regimen that will maintain the downstream riparian system at an acceptable level of productivity.

RIPARIAN ZONE VEGETATION MANAGEMENT PROGRAMS IN THE MISSOURI RIVER DIVISION

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The Operations Division of the Kansas City District is in charge of 18 lake projects in the states of Iowa, Missouri, Kansas, and Nebraska. Responsibility for the Missouri River Bank Stabilization Project is shared with the Omaha District, which also operates 25 lake projects including the 6 Missouri River mainstream projects. These two Districts comprise the Missouri River Division (MRD). Riparian vegetation within the Division is characterized by a cottonwood (*Populus*)-mulberry (*Morus*)-willow (*Salix*) complex in drier grassland regions and a cottonwood-willow-green ash (*Fraxinus pennsylvanica*)-silver maple (*Acer saccharinum*)-sycamore (*Platanus occidentalis*)-pin oak (*Quercus palustris*)-buttonbush (*Cephalanthus occidentalis*) complex in the wetter portions of the Missouri River basin.

Major Programs

Both the Kansas City and Omaha Districts are involved in Permit Programs pursuant to Section 404 of the Clean Water Act and are concerned with the loss of riparian habitats associated with permit activities. Major problems in this regard are how to characterize the value of riparian areas for wildlife and other uses and how to ensure that permit conditions mandating protection of riparian sites are actually followed. An important point is that most riparian habitat losses within the geographical boundaries of the Division are associated with private agricultural activities; thus, they are beyond the control of the Corps of Engineers.

The principal riparian concern at lake projects is land management within reservoir flood pool areas. Repeated flood events quickly leave these sites with only a sparse cover of annual weeds and grasses and make administration of agricultural leasing programs difficult. General shoreline erosion is of concern at all lake projects within MRD, but the large water-level fluctuations, scouring by ice action, and presence of poor soils at many lakes make vegetation establishment along eroding shorelines almost impossible.

As a result, only economically important facilities such as boat ramps, water intakes, roads, and some campground facilities are protected with riprap.

Special Studies

Several special studies involving riparian zones have been initiated in MRD. These are briefly described below.

Republican River. The Kansas City District recently completed a planning study on the Republican River in south-central Nebraska. River flows in this area are significantly affected by irrigation use, and channel aggradation and subsequent willow growth on sandbars have occurred over the past 30 years. One alternative plan to reduce flood damages involved removal of vegetation from the channel; however, this was found to be environmentally and economically unacceptable. Protective levees have been proposed to protect several local areas, but it is not known at this time if future planning will continue on the project.

Little Blue River. The Little Blue River channel project was authorized by the Flood Control Act approved 13 August 1968. It involves channel modifications on approximately 20 miles of stream in rural areas of eastern Jackson County, Mo. A major project feature consists of a new high-flow channel that carries flood flows, while a large part of the original channel functions to carry low stream flows and flood flows less than 5 ft in depth. This design has allowed selected reaches of the original channel and associated riparian vegetation to remain in a more natural condition. Additional information about the project is available from the Kansas City District Planning Division.

Harry S. Truman Reservoir. The Harry S. Truman Dam and Reservoir project involves flood control and hydropower features that impact the downstream environment adjacent to the city of Warsaw, Mo. To address these impacts and to satisfy local environmental concerns, a protective levee and other bank stabilization works were constructed. This project included special plantings of native grasses, trees, and shrubs on the levee backslope to benefit wildlife and improve aesthetics.

Harlan County Lake. Harlan County Lake in south-central Nebraska has been in operation since 1952 for flood control, irrigation, and other project purposes. Irrigation withdrawals and sedimentation have combined to encourage the growth of willow and cottonwood stands on the sediment delta at the upper end of the lake. The resulting problem is how to manage the 2,000 acres of

willow and cottonwood stands that have developed within the multipurpose pool and at points 2 to 3 ft above that elevation. The Kansas City District in cooperation with the Nebraska Game and Parks Commission determined that the "dog-hair" willow stands should be thinned to increase habitat diversity for waterfowl and upland game, while the larger cottonwood stands should be harvested to provide forest openings for expanding turkey (*Meleagris gallopavo*) and white-tailed deer (*Odocoileus virginianus*) populations. Timber management, however, is not a cheap undertaking, and the District has found it difficult to develop commercial interest in the low-value cottonwood timber. Controlled burning may be an alternative if lake levels remain low enough to permit the development of a flammable understory layer.

Summary

A variety of MRD programs are concerned with the preservation, protection, and restoration of riparian vegetation. Vegetation establishment techniques in lake shoreline areas affected by fluctuating water levels are of major interest to the Kansas City District, as are ways to protect or preserve riparian vegetation that would generally have to be removed in the process of constructing small flood protection works.

STRATEGIES FOR RIPARIAN ZONE RESTORATION IN THE ALBUQUERQUE DISTRICT

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The riparian zone is the most limited and biologically important ecosystem in the Southwestern United States, and most Civil Works projects in the region potentially affect this zone. Therefore, measures to restore, rehabilitate, and manage riparian systems are of paramount importance to the Albuquerque District.

Studies of southwestern river systems have shown that they are essential for producing and maintaining much of the biotic diversity of the region. In fact, riparian ecosystems are critical to the occurrence and survival of many plant and animal communities. Although riparian zones represent less than 1 percent of all vegetation communities in the Southwest, they support approximately 80 percent of the fauna.

The most extensive remaining stand of cottonwood-willow (*Populus-Salix*) forest in the Southwest, locally called "bosque" habitat, occurs along the Rio Grande in New Mexico. The vegetation of the upper and middle Rio Grande valleys is unique among southwestern rivers because of the relatively large amount of Fremont cottonwood (*P. fremontii* var. *wislizenii*) and willows, and the relatively low density of salt cedar (*Tamarix chinensis*), an undesirable exotic species that has come to dominate many southwestern riparian zones. Another important feature of this region is the high altitude (4.500 to 6,000 ft above sea level). Most of the riparian forest along the Rio Grande lies either within or adjacent to flood-control levees that parallel the river. The width of the riparian zone ranges from a few feet to over 1,000 ft, with a few hundred feet being the norm. Cottonwoods reach a height of approximately 70 ft in bosque habitats.

Environmental considerations involving both planning and construction in the Albuquerque District include wetland development and restoration in riparian zones, replacement of riparian vegetation, and management of riparian

ecosystems. Measures used to restore and manage riparian zones are described below.

Wetland Development

Wetlands were once an abundant and integral part of riparian ecosystems in the Southwest. However, most of the historical wetlands have been eliminated by agriculture and urban development, and existing wetland habitats are very small, fragmented, and largely relict. District biologists have recognized that there is considerable potential to restore wetlands along leveed flood-control projects by modifying borrow pits created during project construction. Increasing the acreage of marshes and ponds could provide additional habitat for a variety of wetland species, including some that are rare or endangered.

To test the feasibility and wildlife value of modifying borrow areas, an experimental pond ecosystem was developed as a prototype marsh near Albuquerque. A small pond was designed incorporating a variety of slopes, water depths, and shoreline configurations. The pond was constructed in January 1982 in a shallow aquifer with a bulldozer and dragline. The site was sparsely vegetated, and no plantings were made so that natural plant invasion and establishment could be examined. Plant invasion was rapid, and a diversity of wetland species have become established. A complex invertebrate community has also become established, and wildlife use has been high, especially by amphibians and birds. The experimental marsh is approaching its sixth growing season, appears to be feasible, and has been beneficial to wildlife.

Riparian Plantings

Experiments to reestablish and rehabilitate riparian vegetation in the Southwest have been conducted primarily by the Soil Conservation Service (SCS), and the Albuquerque District is currently implementing many of the techniques developed by the SCS. Methods of establishment include the use of whips, bare root plantings, and dormant stock plantings of cottonwood and willow poles and stubs. Willow whips can be cut by hand from existing stands and simply inserted or dug into moist soil. Some species of riparian plants, especially willows, can be obtained commercially in bare root form. Commercial sources of native, bare root, cottonwood trees are being developed.

Plantings of dormant cottonwood and Goodding's willow (*S. gooddingii*) poles (about 2 in. in diameter) and stubs (3 to 6 in. in diameter) have been emphasized to date. Cottonwood poles are obtained from "doghair" stands

during January and February, and the side branches are removed. At the revegetation site, holes are augered to the water table (as deep as 15 ft) or to the capillary fringe; the poles are then inserted, and the holes are backfilled. Trees are usually spaced approximately 20 ft apart, but this varies depending on the type of community structure desired. No rooting hormone is used on the dormant stock plantings. Poles are preferred to stubs if they are to be planted deep. Survival rates for the plantings range from 95 to 100 percent for the first year and average 80 percent for the second year. The SCS has supplied most of the dormant stock to date and is in the process of encouraging private enterprise to develop poles commercially.

Dormant stub cuttings of Goodding's willow and cottonwoods are planted as follows:

1. Stubs are cut with a chain saw; angle cuts are made on the root end, and flat cuts are made on the crown end to prevent planting the cuttings upside down. The cuttings are post size (6 to 7 ft long and 3 to 6 in. in diameter).

2. A hand ax is used to score 12 to 14 in. of the root end.

3. Cuttings are placed with the tops up in barrels full of water. A rooting hormone (Rootone F) is mixed with the water at 1 lb to 35 gal. Cuttings are placed in the water as soon as possible and hauled to the job site in the water.

4. Cuttings are placed in holes, and spaces around stubs are filled with soil and tamped.

5. Melted paraffin is painted on all saw marks; the paraffin will be completely gone after the second growing season. Tree paint has also been used successfully.

An advantage of stub plantings is that a tree of appreciable size is quickly established to provide erosion control and wildlife habitat. Disadvantages are the limited availability of planting stock and the labor required to transport and plant the stubs.

Management of Riparian Ecosystems

Management of riparian cottonwood forests is critical to their preservation and continued value for wildlife and associated recreational uses. Management recommendations for these resources were developed as part of an intensive 2-year biological inventory conducted under contract by the

Albuquerque District. Major recommendations are briefly summarized as follows:

1. Allow for periodic flood disturbances (high flows of short duration) to encourage regeneration of native vegetation.

2. Prohibit vehicles within the riparian woodland.

3. Restore trees by use of pole plantings.

4. Restrict woodcutting, especially cutting of snags.

5. Restrict future residential and commercial development in the adjacent floodplain to a distance not less than 1,000 ft from the riparian forest.

RIPARIAN ZONE MANAGEMENT AT FLOOD-CONTROL RESERVOIRS IN THE LOS ANGELES DISTRICT

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The Operations Branch of the Los Angeles District is responsible primarily for the operation and maintenance of a series of dry reservoirs in southern California. These projects were authorized and constructed to provide local flood protection; under normal conditions, they contain small amounts of water near the dam and become inundated only during major flood events. The projects are located primarily in urban, suburban, and agricultural settings. Almost all of the project land outside of the flood pool is leased to local agencies for recreation development.

Dry reservoirs operated by the Corps in the vicinity of Los Angeles, Calif., include Sepulveda Dam and Reservoir, Hansen Dam and Reservoir, Whittier Narrows Dam and Reservoir, Santa Fe Dam and Reservoir, and Prado Dam and Reservoir. Major environmental problems include impacts on biological resources resulting from development of open lands at the reservoirs, removal of sand and gravel by private contractors, and establishment of appropriate mitigation requirements for development projects. An important regional consideration is that about 95 percent of the original riparian zone has been eliminated along rivers and streams in southern California. Riparian concerns regarding dry reservoirs are discussed below for Sepulveda and Prado reservoirs.

Sepulveda Reservoir

The Sepulveda project is a dry reservoir in a highly urban setting along the Los Angeles River in the San Fernando Valley. Project lands consist of approximately 2,000 acres, 1,527 acres of which are leased to the City of Los Angeles for recreation; some undeveloped areas are leased for agriculture. The project also includes a 50-acre wildlife reserve near the dam, which is being expanded to 110 acres as part of a joint effort between the Corps and the City of Los Angeles. Habitat management in the wildlife area consists primarily of revegetation efforts, including the planting of container stock

of native vegetation. Over 10,000 trees and shrubs have been planted since 1980. Because of the arid climate, newly established plantings require careful watering by hand or with overhead irrigation; mechanical and chemical techniques for weed control are also employed to ensure that plants become established.

In 1979, a 3/4-acre pond was excavated in the wildlife area to provide aquatic habitat. The pond was planted with mature aquatic and emergent plant species. This pond and other wetland areas in Sepulveda basin have been managed intensively in the past few years to minimize the risk of encephalitis, which has been isolated in mosquitoes occurring in the basin. Vegetative restoration in wetland areas of the wildlife reserve has included plantings of Arizona ash (*Fraxinus velutina*), white alder (*Alnus rhombifolia*), western sycamore (*Platanus racemosa*), willows (*Salix* spp.), wild blackberry (*Rubus ursinus*), and desert grape (*Vitis girdiana*). Some of the willows were planted using the dormant stub technique, which involves planting 8- to 10-ft-long cuttings in tree-augered holes; to promote rooting, the bark was scarified on the lower portion of the cuttings, and a rooting hormone was applied. This method has been effective only in irrigated areas due to the depth of the water table.

Expansion of the wildlife reserve includes the development of a 10-acre seasonal pond and establishment of associated wetland vegetation. This wetland system will be supplied with treated sewage effluent. Development of a native California grassland area and a southern oak woodland habitat is also planned as part of the new reserve. Much of the labor required for revegetation efforts will be provided by the California Conservation Corps.

Other riparian communities associated with the project consist of narrow strips along small local drainage channels. Current plans call for vegetation management, including the replanting of these areas with native species such as arroyo willow (*S. lasiolepis*), Fremont cottonwood (*Populus fremontii*), boxelder (*Acer negundo*), and desert grape. Nursery stock of riparian and upland plant species are maintained at a staging area at the wildlife management unit field station at Whittier Narrows Reservoir.

A problem that often affects revegetation efforts is that procedures for riparian zone management often conflict with traditional maintenance practices, including the use of mechanical equipment and herbicides to maintain

urban channels in a vegetation-free state. A riparian study is currently being conducted on the Los Angeles River to determine if viable habitat can be restored along a concrete-sided, soft-bottom channel. A hydraulic analysis is also being conducted to determine effects on flood control.

Prado Reservoir

Prado Reservoir is a 194,000 acre-ft flood-control project on the Santa Ana River in Riverside and San Bernadino Counties, Calif. The project often contains large amounts of impounded water compared with other dry reservoirs. A major environmental concern is that the largest remaining wooded wetland (approximately 5,000 acres) in southern California is located on project lands immediately behind the dam. This high-quality habitat provides nesting and foraging areas for many sensitive species, including a newly listed endangered species, the least Bell's vireo (*Vireo bellii pusillus*). Prado basin is also home for over 200 species of birds and numerous species of mammals, reptiles, and amphibians. Protection of this sensitive area is a critical problem for the Corps, especially since the areas surrounding the basin are developing rapidly and all recreational lands associated with the project are leased to local governments and private interests. An additional problem for the basin's resources is an approved plan for major alteration of the dam.

Comments

One of the most critical problems facing resource managers in the Los Angeles District is the intense urbanization of most of southern California. Much of the remaining riparian habitat in the region is associated with reservoirs or channels owned or maintained by the Corps of Engineers. This presents a real challenge as we attempt to balance flood-control requirements with the need to preserve important and sensitive riparian zones.

RIPARIAN ZONE CONCERNS IN THE SOUTH PACIFIC DIVISION

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Riparian zone issues in the South Pacific Division primarily involve mitigation for project-related losses and maintenance of existing riparian habitats. Protection and restoration of urban riparian habitats are major problems in some areas. Selected projects in the Sacramento District are discussed below; Mr. Rick Harlacher previously addressed riparian concerns in the Los Angeles District.

Lake Sonoma/Warm Springs Dam

The Warm Springs project is located northeast of San Francisco, Calif., along Dry Creek, a tributary of the Russian River. The project was authorized in 1963, prior to the implementation of the National Environmental Policy Act. At that time, fish and wildlife interests were primarily species-related, and no special attempt was made to mitigate for lost riparian habitat. Prime concerns were for anadromous fish, mule deer (*Odocoileus hemionus*), and peregrine falcon (*Falco peregrinus*). Channel improvements downstream from the dam were made with little regard for riparian habitat, and it has not been determined whether this work was beneficial or damaging to the corridor. The Russian River supports a diverse riparian ecosystem, and attempts were made to justify habitat acquisition along Dry Creek during the construction phase of Warm Springs Dam. However, efforts were unsuccessful due to strong opposition from area landowners.

Sacramento River Bank Protection Project

This project was authorized in 1960 to preserve the extensive Sacramento River Flood-Control System, with its network of about 1,000 miles of levees,

bypasses, weirs, and other structural features. Due to agricultural development, only remnant riparian vegetation remains in the Sacramento Valley, much of which is associated with the levee system. Bank protection often results in adverse environmental impacts, but an active coordination program has been established among the Corps of Engineers, the State Reclamation Board (project sponsor), US Fish and Wildlife Service (FWS), and the California Department of Fish and Game to develop mitigation measures to replace lost riparian habitat. A series of supplemental Environmental Impact Statements has been prepared to facilitate mitigation efforts, and the FWS Habitat Evaluation Procedures were used extensively to assess mitigation needs.

Sacramento River, Chico Landing to Red Bluff Project

The Chico Landing to Red Bluff project (authorized in 1958) is a continuing construction project that has been halted by an FWS Endangered Species jeopardy opinion. The opinion provides that further bank protection in the area jeopardizes the survival of populations of the threatened valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*). The beetle occurs only in habitat provided by a species of elderberry (*Sambucus mexicana*), an important riparian shrub found in the project area. Riparian habitat has diminished to a remnant of its former abundance in this portion of the Sacramento Valley due primarily to agricultural development. Bank protection measures provided by the project would cause further losses and eliminate river meandering, which are important for the preservation of riparian vegetation and associated fish and wildlife species.

Urban Projects

The Indian Bend Wash Greenbelt Floodway in the vicinity of Phoenix, Ariz., occurs largely in an urban setting. The floodway was designed primarily for intensive recreation, and little opportunity was allowed for riparian habitat management. The project is characterized by a riprap channel and rocks set in concrete. Some trees have been planted, but providing habitat for wildlife was not a consideration. Other problems at the project include fire dangers, the presence of hobo hideouts, and stands of vegetation too dense to provide optimum wildlife use.

The Corte Madera Creek project (located along a tributary that drains into the northern part of San Francisco Bay) is an urban project in the General Design Memorandum stage. Although there is limited space available for

riparian mitigation, coordination with the FWS and California Department of Fish and Game has resulted in a plan for protection of existing habitat. The Wildcat-San Pablo Creek project (along the eastern shore of San Francisco Bay) is currently under construction. A well-accepted riparian vegetation mitigation program has been developed for this project by the sponsor, FWS, Corps of Engineers, and a design team of local organizations.

Extensive flooding in California in February 1986 resulted in several initiatives to protect existing levee systems and improve the level of flood protection in metropolitan areas along the American and Sacramento Rivers. Mitigation of impacts to riparian vegetation, and possibly enhancement, will be included as important considerations in these studies.

Special Initiatives

As a result of flood-control feasibility studies, the Sacramento District and FWS recently identified a tentative proposal to preserve 10,000 acres of remnant riparian habitat along the Sacramento River through the establishment of a national wildlife refuge. Local citizen groups are strongly supportive of congressional authorization and appropriations to protect this important resource, and the FWS is presently conducting a feasibility analysis of the proposal. Additionally, the Sacramento River Task Force (a California legislature initiative known as Assembly Bill 1086) plans to address riparian zone protection that would be complementary and supplementary to the proposed Sacramento River National Wildlife Refuge.

Conclusions

Protection of riparian vegetation is an important consideration for Corps projects in the Sacramento District. The District is very active in coordinating with other agencies regarding potential project impacts and mitigation needs for riparian habitats. Projects discussed above represent just a few of the many riparian issues being addressed in the South Pacific Division.

RIPARIAN ZONE MANAGEMENT IN THE NORTH PACIFIC DIVISION

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The North Pacific Division encompasses Alaska, Idaho, western Montana, Oregon, and Washington. Major missions for the Division include hydropower, navigation, flood control, irrigation, water supply, recreation, and fish and wildlife. North Pacific Division's emphasis on fish and wildlife management has been heightened by passage of the 1980 P. L. 96-501, Pacific Northwest Electric Power Planning and Conservation Act (16 U.S.C. 839 et seq.), and implementation of the Columbia River Basin Fish and Wildlife Program for the main stem of the Columbia River and its tributaries. Management programs in the basin are accomplished through the practical and integrated application of good stewardship, mitigation, and enhancement concepts. Much of the interest in fish and wildlife and the application of the above management concepts are focused on the riparian corridor.

Riparian Management

Many conflicting interests compete for riparian corridors in the Division, as is the case in most of the Western States. Among the various interests continually drawing on the resource are recreation (fishermen, backpackers, boaters), transportation services (highways and railways), agriculture (croplands and livestock), and industry (port authorities and industrial parks). These are conflicts that must be resolved through the master planning process when associated with a Corps-administered project. Much of the riparian corridor could be protected and managed if it were properly classified as an important resource. However, this ecosystem is not treated adequately within existing Corps policy and guidelines.

Inventories of wildlife and wetland resources have been conducted along many of the major riparian corridors in the North Pacific Division. These have provided essential baseline information, and many management units along these corridors are now monitored on a regular basis to provide an evaluation

of management strategies used. Current management practices associated with riparian habitat on Corps projects include management of wintering areas and travel lanes for mule deer (*Odocoileus hemionus*), Columbian black-tailed deer (*O. h. columbianus*), and elk (*Cervus elaphus*); maintenance of roost sites and feeding habitat for raptors; provision of artificial nest structures for cavity-nesting birds; and development of pastures for Canada geese (*Branta canadensis*).

The North Pacific Division is attempting to accomplish riparian zone management through a "good stewardship" concept to supplement ongoing mitigation and enhancement programs. However, the policies and procedures that incorporate the various authorities, philosophies, and measures into a single land management ethic are lacking. The offices of Planning and Construction-Operations at Corps Districts would mutually benefit from a program that addresses riparian zone issues in the development of guidance for lakeshore management, streambank protection, and channel maintenance.

Riparian Needs

Although the North Pacific Division has placed considerable emphasis on riparian zone management, additional studies and information are needed to do a more effective job. Examples of study needs are as follows:

1. Demonstration sites would provide information on practical shore and soil stabilization techniques useful to Corps resource managers and biologists. The McNary experimental pond, constructed and operated under the Environmental Water Quality and Operations Program, should be continued as a demonstration site.

2. Biologists and engineers should work together as a team to address bioengineering techniques along riprapped streambanks and levees. Such efforts could result in the development of technology to increase the functional size of the riparian corridor while maintaining the integrity of structural features.

3. Research and evaluation of setback levees along the braided river systems of the West (such as those occurring on the Heisse-Roberts and the Jackson flood-control projects in the Walla Walla District) could provide immediate and practical applications to existing levee maintenance problems.

PART III: SUMMARY OF WORKSHOP DISCUSSION

Each presentation was followed by a brief discussion period, and extensive group discussions were held at the end of the first day's session and on the final day of the workshop. Discussion sessions were also conducted at points of interest during the field trip. Major issues are summarized under selected headings below.

Riparian Zone Definition

Workshop participants agreed that the riparian zone is a corridor consisting of vegetation zones with decreasing moisture tolerances extending as a continuum from the water's edge to some upland location designated by changes in biological, hydrologic, and physiographic characteristics. According to some authorities, the riparian zone is an area identified by the presence of vegetation that requires free water or conditions more moist than normally found in the area. Although wetland areas often occur within riparian ecosystems, the riparian zone will not be considered here as a wetland habitat type.

Several riparian zone definitions were suggested and discussed by workshop participants. It was decided that the following elastic definition for riparian zone restoration and management would best suit the purpose of the work unit--"action taken to restore and manage indigenous vegetation communities directly influenced by the hydrologic regime and geomorphology of the watercourse." Emphasis should be placed on how restoration and management affect all the resources of the riparian system, including their uses.

Regional variation in riparian ecosystems was discussed, and several District representatives compared characteristics among their geographical areas. Annual precipitation and flooding frequency and duration were noted as major factors influencing the character of riparian habitats. Ephemeral western streams and headwater areas often do not support vegetation communities typical of riparian conditions, but it was agreed that they should be addressed in the work unit because they are an integral part of the riparian ecosystem as a whole. Although several presentations included information on reservoir shorelines, it was decided that lacustrine systems would not be

treated specifically as part of the work unit. However, tributaries that enter reservoirs and tailwater areas will be included.

Riparian Functions and Values

The functional importance of riparian ecosystems was discussed at length. Benefits associated with riparian zone protection and restoration include erosion control and bank stabilization, water quality and fishery enhancement, provision of recreational opportunities, improved aesthetics, and restoration of wildlife habitats. The riparian zone functions physically to provide shade, retain sediment, and absorb water, while biologically serving as an ecotone that provides essential habitat for a distinctive flora and fauna. The riparian corridor serves as critical habitat for many wildlife species, and the majority of western plants and animals designated as endangered, threatened, or otherwise sensitive, occur within this zone.

From a planning perspective, several District representatives recommended that an in-depth investigation of riparian zone functions and values be conducted. Questions to be addressed include: What is the total area of influence, and how are riparian zones unique as functional ecosystems? What physical and vegetative features are needed for riparian zones to be optimally productive? How much vegetation and what characteristics (dominants, species diversity, vertical and horizontal layering, etc.) are required for a functional system? What spatial attributes (length, width, total area, shape, continuous versus fragmented) are needed to obtain specific benefits and achieve management objectives? How do various land uses, Civil Works projects, and human activities affect the functional values of riparian zones? How can riparian corridors best be managed to ensure their functional integrity? Finally, it was strongly recommended that riparian zones be assessed regionally to provide comparative information on their value.

Conflicting Land Uses

Corps projects are strongly influenced by surrounding land uses, including agriculture, grazing, industry, urbanization, and recreation. Adverse impacts of these activities are often detrimental to the riparian zone and the

stream itself, especially where a protective buffer strip is not established and maintained as part of the project plan. This situation can lead to long-term degradation of water quality, fisheries, and recreational resources, thus eliminating many of the economic benefits that could have been achieved through project construction.

Several Districts indicated a particular need to develop guidelines for riparian zone restoration and protection in urban settings. Tributaries entering reservoirs are influenced by urban development upstream of the project, and tailwaters and downstream areas are attractive to high-density recreational activities such as boating and rafting. Thus, secondary impacts of project construction can have a significant impact on the riparian corridor. Many local flood-control projects in urban areas consist of channel modifications and bank protection using only structural techniques. These sites could be improved aesthetically and environmentally by using biotechnical methods and planting native vegetation.

Project designs should emphasize balanced uses in urban settings, and low-density rather than intensive recreational activities should be planned to minimize environmental impacts. Water quality problems are severe in many urban areas, and the establishment and protection of buffer strips should be an integral part of project design. The agency or organization responsible for maintaining the quality of riparian zones must be firmly established during project planning.

Bank Restoration/Bioengineering

A major concern of most Civil Works projects is the provision of bank protection and shoreline stabilization to prevent erosion and sedimentation and to reduce adverse impacts of project construction. From an environmental and economic perspective, workshop participants agreed that bank restoration and stabilization are best achieved through a bioengineering approach. A variety of biotechnical methods have been developed in Europe and the United States; these should be examined as part of the work unit, and suitable methods for Civil Works projects should be described in detail in a Corps guidance document. To facilitate technology transfer, the group agreed that a bioengineering workshop (to include presentations by international experts)

should be planned for the riparian work unit. This perhaps could be sponsored by the American Society of Civil Engineers (ASCE).

Workshop participants agreed that bank restoration should employ the use of native plant materials as much as possible. However, information is lacking on suitable plant species and revegetation techniques, and nursery stock is often difficult to obtain commercially. Therefore, the development of regional riparian plant species lists, requirements for site preparation, and planting guidelines should be developed as part of the work unit. Several Corps Districts and other government agencies have developed information that could be included in this effort.

Civil Works Projects and Authorities

All District and Division representatives at the workshop reported that riparian zone planning and management were important environmental issues within their areas of jurisdiction. Several participants stated that there was an urgent need for the Corps of Engineers at large to recognize the broad environmental values and national significance of riparian ecosystems and to develop strategies and guidance for their protection and management. The riparian zone is most important as a policy issue in the 11 Western States (including the Corps North Pacific Division, South Pacific Division, Southwestern Division, and Missouri River Division), where much of the riparian habitat has been destroyed and where State water rights are a major issue. However, workshop presentations have shown that streamside corridors are also highly valued resources in the Central and Eastern States.

Riparian zone protection and management are concerns of both Planning and Construction-Operations functions of the Corps of Engineers. Local flood protection projects are often implemented under Sections 205 and 208 of the Continuing Authorities Program (ER 1105-2-50). This authority allows projects to be constructed in such a way that impacts to streams and their floodplains are minimized, but a long-term management commitment to the riparian corridor is usually lacking. Thus, a need was identified to redefine and reissue Corps instructions for Operation and Maintenance activities at local flood-control projects, as they pertain to the protection and restoration of riparian vegetation.

It was suggested that the riparian corridor needs to be incorporated as a land-use classification in master plans prepared for water resource development projects. The purpose of a master plan is to organize the multipurpose goals of a Corps project into a coherent scheme for management. Where other programs affecting the corridor apply, these should be included in the master plan or in another appropriate document, such as a Feature Design Memorandum or an exhibit in a Memorandum of Agreement. Approval of the master plan or other documents and the subsequent funding of the work provide the authority to conduct proper management on a sustained basis over time.

All District and Division participants recognized a need to address riparian zone management within and along levee systems. The impacts of contiguous land uses and urban development were expressed as major concerns for most Civil Works projects. Finally, workshop participants agreed that techniques and Corps guidance for monitoring riparian corridors are urgently needed.

Work Unit Concensus Items

The following items were agreed upon by workshop participants as major tasks for the work unit.

1. Synthesize available information regarding riparian zone restoration and management, and develop a procedure for transferring technology to the field. The information should be prepared in a way that it can be used as a planning tool.

2. Coordinate work unit activities with other agencies and organizations involved with riparian zone management.

3. Conduct a broad analysis of riparian functions and values. Benefits and uses of riparian systems should be evaluated from a regional perspective and related to the US Fish and Wildlife Service "resource categories."

4. Provide information on bioengineering approaches for vegetation establishment and bank protection appropriate for riparian zones. Emphasize the use of native plant materials, and provide regional guidelines on species and planting techniques. Plan a bioengineering workshop as a future event for the work unit, perhaps to be cosponsored by the ASCE.

5. Arrange to have riparian zone restoration and management as a major topic for discussion at a future meeting of the Chief of Engineers' Environmental Advisory Board.

6. Obtain information on successful riparian zone management programs at Corps projects, and prepare a report of case studies.

7. Survey site-specific riparian management activities at Corps projects, and select demonstration projects for analysis and monitoring.

8. The final product for the work unit should be a Corps of Engineers guidance document on procedures for riparian zone restoration and management to achieve multiple environmental benefits.

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APPENDIX B: PLAN OF STUDY: DEVELOPMENT OF GUIDELINES FOR RIPARIAN ZONE RESTORATION AND MANAGEMENT

Riparian zones are extremely important and sensitive ecosystems, and their proper management and protection are often essential to achieving environmental benefits at Civil Works projects. The development and management of riparian habitats are also viable mitigation alternatives for many Corps projects. To address these issues, a new research and development work unit entitled "Development of Guidelines for Riparian Zone Restoration and Management" was initiated in FY 1986 by the Environmental Impact Research Program (EIRP) of the Office, Chief of Engineers, US Army.

The following elastic definition for riparian zone restoration and management has been selected for the work unit--"action taken to restore and manage indigenous vegetation communities directly influenced by the hydrologic regime and geomorphology of the watercourse." Emphasis will be placed on how restoration and management affect all natural resources of the riparian system, including their uses.

Objectives

The purpose of the work unit is to examine and develop information on the management of riparian ecosystems and provide technology to US Army Corps of Engineers (CE) Districts on revegetation and stabilization of streambanks, assessment of riparian habitat, and development of habitat management strategies for riparian zones. Emphasis will be on (a) determination of essential functions and values of riparian systems; (b) assessment, design, and development of riparian corridors; (c) riparian habitat management and revegetation methods; and (d) methods for erosion control and bank stabilization.

Application

The work unit has broad application to the CE as many projects (e.g., local flood control, permit actions, reservoir operations) influence riparian systems to a large degree. Thus, riparian concerns are important to a variety

of Corps functions and involve CE Planning, Engineering, Construction-Operations, and Regulatory offices. Although several Districts are actively managing streamside areas, there is currently no CE guidance on riparian restoration and management practices appropriate for Civil Works projects. Information developed through the work unit will result in substantial environmental benefits at Corps projects nationwide.

Background

Riparian zone status and importance

The protection of dwindling riparian resources has been an important environmental issue in the United States since the 1960s. To address the problem, several government agencies have developed programs that deal specifically with riparian ecosystems, and three national and international symposia (in 1977, 1978, and 1985) have been sponsored by the US Forest Service and National Park Service along with other Federal and State agencies, universities, and private organizations; the CE participated as a cosponsor of the 1978 symposium. State and regional workshops have also been held, and several Corps offices have conducted studies of riparian habitats associated with their projects.

The inherent values of riparian zones have been documented in numerous studies. Some of the widely accepted benefits resulting from protection and restoration of riparian corridors are as follows:

1. Riparian zones function as a buffer to protect streams and rivers from the potential impacts of adjacent land uses. As such, they serve as a filter to reduce the effects of agriculture, industry, and urbanization on water quality and aquatic resources.

2. Stable riparian vegetation reduces streambank erosion, provides shade, and contributes organic matter to the stream, thereby improving water quality and fish habitat.

3. Riparian ecosystems are aesthetically important and offer scenic relief from monotonous man-dominated landscapes such as agricultural, residential, and industrial areas. In many areas, development of greenbelts along waterways has become an important part of urban and regional planning.

4. Riparian zones provide important consumptive and nonconsumptive recreational opportunities.

5. Riparian ecosystems are extremely important wildlife habitats. They provide essential food and cover for a variety of species, provide critical nesting habitat, serve as corridors for movement and allow access to available water. Nationwide, a disproportionate number of fish and wildlife species depend on riparian habitats for survival; these include many threatened and endangered species.

Major issues and information needs

A CE workshop on riparian zone restoration and management was held in San Antonio, Tex., on 24-27 February 1986. The purpose of the workshop was to present the concept of the work unit and to ensure that the study addressed major planning and operational needs within the Corps. Major concerns expressed by workshop participants are summarized below.

Corps projects are strongly influenced by surrounding land uses, including agriculture, grazing, industry, urbanization, and recreation. Adverse impacts of these activities are often detrimental to the riparian zone and the stream itself, especially where a protective buffer strip is not established and maintained as part of the project plan. This situation can lead to long-term degradation of water quality, fisheries, wildlife, and recreational resources, thus eliminating many of the economic benefits that could have been achieved through project construction.

A major concern at most Civil Works projects is the provision of bank protection and shoreline stabilization to prevent erosion and sedimentation and to reduce adverse impacts of project construction. From an environmental and economic perspective, workshop participants agreed that bank restoration and stabilization are best achieved through a bioengineering approach using native plant materials as much as possible. However, information is lacking on suitable plant species and revegetation techniques, and nursery stock is often difficult to obtain commercially.

All District and Division representatives at the workshop reported that riparian zone planning and management were important environmental issues within their areas of jurisdiction. Several participants stated that there was an urgent need for the CE at large to recognize the broad environmental values and national significance of riparian ecosystems and to develop

strategies and guidance for their protection and management. Administratively, riparian zone protection and management are concerns of both Planning and Construction-Operations functions within the CE.

The following items were agreed upon by workshop participants as major tasks for the work unit:

1. Synthesize available information regarding riparian zone restoration and management, and develop a procedure for transferring technology to the field. The information should be prepared in a way that it can be used as a planning tool.

2. Coordinate work unit activities with other agencies and organizations involved with riparian zone management.

3. Conduct a broad analysis of riparian functions and values. Benefits and uses of riparian systems should be evaluated from a regional perspective and related to the US Fish and Wildlife Service "resource mitigation categories."

4. Provide information on bioengineering approaches to vegetation establishment and bank protection appropriate for riparian zones. Emphasize the use of native plant materials, and provide regional guidelines on species and planting techniques. Plan a bioengineering workshop as a future event for the work unit, perhaps to be sponsored by the American Society of Civil Engineers or a similar society that would draw an engineering audience as well as biologists.

5. Arrange to have riparian zone restoration and management as a major topic for discussion at a future meeting of the Chief of Engineers' Environmental Advisory Board.

6. Obtain information on successful riparian zone management programs at Corps projects, and prepare a report of case studies.

7. Survey site-specific riparian management activities at Corps projects to select demonstration projects for analysis and assessment.

8. The final product for the work unit should be a CE guidance document on proper procedures for riparian zone restoration and management to achieve multiple environmental benefits.

Work Unit Approach

The goals of the work unit will be accomplished in two major phases. Phase I (Project Scoping and Information Synthesis) will include coordination with other Federal agencies having responsibilities for riparian zone management, review of the technical literature, and consultation with CE District personnel to identify specific problems and information needs. Phase II (Problem Solving and Technology Transfer) will include riparian site visits and problem-oriented field studies, planning and presentation of an international workshop on riparian restoration methods, and preparation of reports.

Phase I

Phase I has been partly completed with the initiation of a literature survey and successful presentation of a planning workshop attended by 10 representatives of CE Districts and Divisions. Project scoping will also involve a review of riparian zone policies and procedures of other Federal agencies including the Bureau of Land Management, Bureau of Reclamation, Fish and Wildlife Service, Forest Service, National Park Service, and Soil Conservation Service. Work unit activities will be coordinated with representatives of these agencies to avoid duplication of effort and ensure that products will be useful to a wide audience. Additional consultation and visits to selected CE Districts will be used to identify field sites needed in Phase II of the work unit.

Phase II

A major product of the work unit will be the development of a workshop to communicate the latest technology for riparian zone protection, restoration, and management to CE personnel and other interested parties. The workshop will feature national and international experts on subjects such as biotechnical approaches to streambank stabilization, selection and propagation of indigenous riparian plants, and design of riparian corridors and buffer strips. Various options for presenting the workshop will be explored, including the possibility of holding it in conjunction with an annual meeting of the American Society of Civil Engineers. Papers based on the presentations will be published in a proceedings of the workshop and distributed to all CE Districts and Divisions.

Selected field sites will be visited to develop case studies useful in CE planning and operations. Outstanding examples of riparian zone restoration and management performed by Districts will be described and published in cooperation with the personnel involved. Existing data will be compiled and analyzed and, where necessary, new data will be collected to evaluate the success of riparian zone improvements. The case studies will include recommendations for the design and execution of future restoration projects.

Additional tasks within Phase II will be initiated as necessary to address specific riparian management problems raised by CE District personnel. Possible topics include the prediction of downstream impacts resulting from altered streamflow regimes, determination of minimum riparian area and configuration for important wildlife species and guilds, and adaptation of computer software and modeling approaches to riparian zone planning. Selected information needs will be addressed through problem-oriented field studies and/or computer simulation.

There will be four major reports from the work unit: (a) a synopsis of the planning workshop; (b) a review of riparian zone functions and values; (c) a report of case studies of Corps stream restoration activities; and (d) a final report of guidelines for riparian zone evaluation, restoration, and management. The review of functions and values will be written from a regional viewpoint and will emphasize minimum design requirements for riparian corridors to fulfill essential functions. The final guidelines report will include the latest bioengineering approaches to streambank stabilization, design of riparian habitats for wildlife mitigation and enhancement, and recent technology for assessing and monitoring long-term changes in riparian zone conditions. Additional products of the work unit will include a proceedings of the international workshop on riparian restoration methods, perhaps published in cooperation with a major professional society, and reports of specific problem-oriented studies, as needed.

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